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Implications of Uncertainty about Long-Run Inflation and the Price Level

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The views expressed in this paper are those of the author.
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Abstract

This paper surveys recent developments in the theoretical and empirical literature on the economic implications of uncertainty about the longer-term outlook for inflation. In particular, the linkages between inflation, long-run inflation uncertainty, and aggregate economic activity in industrial economies have become considerably better understood during the past decade. In the case of Canada, there is evidence that uncertainty about long-run inflation fell considerably between the high-inflation period of the 1970s and early 1980s and the subsequent moderate-inflation period, and decreased still further in the low-inflation period that has been evident since the early 1990s. As a result, both businesses and households have increasingly used longer-term financial instruments to meet their financing needs over the past two decades. In general, recent empirical work for Canada and elsewhere considerably strengthens the view that reductions in long-run inflation uncertainty can have beneficial effects on financial markets, capital spending, and ultimately aggregate levels of economic activity. Recent theoretical developments have improved our understanding of why this is so.

JEL classification: E22, E31, E44
Bank classification: Inflation: costs and benefits

Résumé

L'auteur passe en revue les travaux théoriques et empiriques qui ont récemment été consacrés aux conséquences économiques de l'incertitude entourant les perspectives à long terme en matière d'inflation. Au cours de la dernière décennie, des progrès importants ont été accomplis dans la compréhension des liens entre l'inflation, l'incertitude liée à celle-ci en longue période et l'activité économique dans les économies industrielles. Au Canada, il semble bien que cette incertitude ait beaucoup diminué entre la période de forte inflation observée durant les années 1970 et au début des années 1980 et la période subséquente d'inflation modérée, et qu'elle se soit atténuée encore au cours de la période de faible inflation amorcée au début des années 1990. Aussi les entreprises et les ménages ont-ils de plus en plus recours au financement à long terme depuis deux décennies. Dans l'ensemble, les études empiriques ayant porté récemment sur le Canada et d'autres pays confortent le point de vue selon lequel une baisse de l'incertitude entourant l'inflation à long terme peut avoir des retombées bénéfiques sur les marchés financiers, sur les investissements et, au bout du compte, sur le niveau de l'activité économique. Grâce aux progrès récents de la théorie, nous comprenons mieux aujourd'hui les différents facteurs à l'œuvre.

Classification JEL : E22, E31, E44
Classification de la Banque : Inflation : coûts et avantages

1. Introduction

The costs of inflation have generated an extensive literature in recent years (Coletti and O'Reilly 1998, O'Reilly 1998, Ragan 1998, Temple 2000). In the simplest macroeconomic models, inflation makes it expensive to hold currency and therefore results in non-productive efforts by economic agents in converting currency into other assets. As well, a higher rate of inflation and the subsequent rapidly rising price level leads to larger economic distortions when institutions, such as nominal accounting practices, are based on the assumption of a stable unit of account (O'Reilly and Levac 2000, Bank of Canada 2001). Higher rates of inflation also tend to increase uncertainty regarding the longer-term outlook for inflation, thereby increasing the proportion of transactions that are based on relative prices that are not close to their fundamental levels.

In this paper, it will be argued that this latter effect of higher inflation, the increase in uncertainty about the long-run inflation rate, results in quantitatively significant costs to the economy. For instance, long-term financial markets function much less effectively when there is a substantial increase in both inflation and inflation uncertainty. As a result, greater long-run inflation uncertainty adversely affects capital formation and therefore the level of aggregate economic activity. In the case of Canada, long-run inflation uncertainty has fallen considerably between the high-inflation and low-inflation periods, contributing in particular to a substantial rise in the use of longer-term financing by both businesses and households.

Section 2 describes various channels through which an increase in uncertainty about long-run inflation might affect the economy. Sections 3 and 4 review the empirical evidence on both the effects of inflation on inflation uncertainty and the impact of inflation uncertainty on the real economy and financial markets. Section 5 concludes with an assessment of the key insights to be drawn from the recent literature on the economic effects of inflation uncertainty.

2. Economic Activity and Uncertainty Regarding Long-Run Inflation: Theory

Uncertainty refers to situations in which the probability of future events cannot be determined (Drèze 1999). This is in contrast to a risky event for which an explicit probability can be assigned. Future volatility in an economic variable is the sum of both predictable and unpredictable components. The uncertainty of an economic variable can then be more precisely defined as its unpredictable volatility (Crawford and Kasumovich 1996, Grier and Perry 1998).

Intuitively, inflation uncertainty is the degree to which the future inflation rate is unknown in the sense of not being predictable, given past performance (Golob 1993). Similarly, long-run price-level uncertainty is the extent to which the longer-term path of the price level is unpredictable. As might be anticipated, these concepts are closely linked but still distinct. For instance, a central bank might aim to achieve a low inflation rate but still allow base drift in the price level. In this situation, it would be easy to predict the inflation rate, whereas the degree of unpredictability of the price level, especially over the longer term, would remain quite high (Selody 1993). All the same, a high level of long-term inflation uncertainty would still imply a high level of price-level uncertainty.[1]

With these points in mind, recall that economic decision-making is normally predicated on the assumption that money is a stable standard of value, or in other words, that economic agents can reliably predict a path for the aggregate price level (Konieczny 1994). If there is a substantial rise in uncertainty regarding the future path of aggregate prices, then it becomes much riskier for agents to hold unindexed longer-term nominal assets (Fischer and Modigliani 1978). In monetary regimes where trend inflation is very difficult to predict, one might expect agents to develop an increased preference for flexibility in their portfolio choices. A rise in the variability of beliefs about the future path of the aggregate price level would then lead to an increase in demand for shorter-term assets and a reduction in demand for longer-term financial assets (Jones and Ostroy 1984). Indeed, it is a stylized fact that many of the markets for longer-term financial contracts disappear when the inflation process is characterized by a high degree of unpredictability.[2]

Why would these markets disappear?[3] Heymann and Leijonhufvud (1995) start from the assumption that money and nominal contracts are needed because economic agents have limited abilities to make economic calculations. With a marked increase in both the level and volatility of inflation, traders in long-term financial markets will have much greater uncertainty about the future course of monetary policy and future rates of inflation. High and unexpected inflation is more likely to redistribute wealth in arbitrary ways between parties to existing nominal contracts, especially because asset markets are already incomplete (Neumeyer 1999). The volume of trading in longer-term financial instruments would diminish appreciably and could indeed disappear.

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1. In the subsequent discussion in this section, it will become clear that, ultimately, aggregate price-level uncertainty leads to adverse effects on aggregate economic activity. However, most of the empirical literature has focused on the relation between inflation uncertainty and aggregate output, given that both inflation and price-level uncertainty were high in most industrial countries during the 1970s and 1980s.
2. When inflation is highly unpredictable, it is said to be characterized by a unit root.
3. In the next few paragraphs, the discussion of issues in Heymann and Leijonhufvud (1995) has been extremely helpful.

Moreover, it would be much more difficult for investors to assess the actions of central banks and the reactions of markets to such actions over longer-term horizons. As a result, investors would find it more difficult to make reliable decisions about investments in longer-term financial instruments, which would also tend to lead to decreased activity in these markets.

Indeed, the recent theoretical literature focusing on informational asymmetries in credit markets shows how higher rates of inflation can impair the effective functioning of the financial sector, including financial markets, even in low-to-moderate inflation economies (Boyd, Levine, and Smith 2001). An increase in the rate of inflation lowers the real rate of return on all financial assets, thereby increasing the level of frictions in credit markets and consequently reducing investment spending (Huybens and Smith 1999). A positive rate of inflation could also introduce a distortion between the investor's perceived value of the firm, as reflected in the stock price, and the firm's perception of its own value, as reflected in the expected discounted value of dividends (Chami, Cosimano, and Fullenkamp 1999). In addition to the usual reductions in rates of return on both money balances and nominal dividends arising from an increase in inflation, the rate of return on the nominal value of equity would then be lower (Chami, Cosimano, and Fullenkamp 2001).

Increased uncertainty regarding the long-run level of inflation and the aggregate price level, together with the associated disruption and disappearance of longer-term financial markets, is likely to have an adverse effect on investments in long-term assets, whether financial or physical. Economic agents need reliable estimates of the future path of aggregate prices to correctly assess the value both of their existing wealth and prospective investment projects. Even in moderate inflations, there is likely to be greater dispersion in the distribution of inflation expectations held by agents, so that it becomes more difficult to measure the "real interest rate" and therefore judge what would be the real rate of return on capital invested in a long-term project. Since intertemporal valuations are less likely to be consistent, economic agents have to make higher-than-usual efforts to reconcile intertemporal demands and supplies, resulting in a welfare loss. More generally, high inflation tends to result in more frequent misperceptions of relative price changes (particularly real cost changes) by agents (Harberger 1998). Firms and households are less able to assess the underlying rate of change in relative prices during serious inflationary episodes, since individual nominal prices are adjusting to monetary shocks at very different rates. The increased difficulty both in undertaking longer-term investment projects and in properly assessing underlying changes in relative prices implies that the process of productivity change is likely to be impaired. For example, it becomes much harder to correctly account for the depreciation of capital goods during periods of even moderate inflation and therefore to properly

measure the real cost of capital goods, as taxation and accounting systems are typically designed to be used in an economic environment where the aggregate price level is stable.

It has often been suggested that some of these problems might be alleviated by the widespread adoption of indexation in contractual relationships. In fact, explicit indexation practices were not commonly used in Canada during the period of the 1970s and early 1980s, aside from the following developments: governments in Canada indexed most of their major transfer payment programmes, indexation was implemented in the personal income tax system, and many negotiated wage agreements included cost-of-living clauses. In high-inflation economies, however, intermediate-term contracts have usually been indexed, while transactions in real estate and some durable physical assets have often been "dollarized" (Heymann and Leijonhufvud 1995). Even in these latter economies, very short-term contracts continued to be expressed in nominal terms.

There are a number of reasons why indexation is not commonly adopted in moderate-inflation economies. First, it is difficult for both parties to a contract to agree on a common indexation formula. For instance, significantly different expectations between an employer and a union regarding both CPI inflation and changes in the firm's producer price may preclude agreement on an indexation formula during wage negotiations. These problems may exacerbate to the extent that moderate rates of inflation contribute to greater volatility in relative prices.[4] Coordination problems may be an additional factor, because of the costs associated with negotiating indexation clauses in a multitude of individual contracts (Shiller 1998). As well, the increased price-prediction errors that can be expected to result from higher rates of inflation should shorten the duration of new contracts (Canzoneri 1980). Indeed, there is empirical support for a negative relation between inflation uncertainty and wage-contract duration in both Canada and the United States (Christofides and Wilton 1983, Rich and Tracy 2000).[5]

Furthermore, the use of indexation in itself involves a substitution between differing types of risk, as fluctuations in the aggregate price level reflect both monetary and real (relative price) shocks (Magill and Quinzii 1996). Agents choosing nominal contracts over real contracts wish to avoid the risk associated with real shocks. When the variability of underlying inflation is low compared to that of relative prices, many agents would therefore prefer nominal contracts. Furthermore, the widespread adoption of wage indexation linked to lagged inflation in high-inflation economies

4. The evidence for substantial volatility in relative prices is particularly clear in high-inflation economies (Heymann and Leijonhufvud 1995).
5. Moreover, these two studies indicate that the frequency of inflation indexation increases with higher levels of inflation uncertainty.

may make it even more difficult for the monetary authority to stabilize output, especially if the economy is significantly affected by external supply shocks (Duesenberry 1997, Jadresic 1998).

Psychological misperceptions may partly explain resistance to indexation proposals. For instance, surveys of individuals indicate that history is often perceived not to be a guide to the future, so that many people do not consider past movements in aggregate price levels to provide information regarding future price-level uncertainty (Shiller 1998, 1999). Indeed, such views are often held in both low-inflation and high-inflation countries. There is also empirical evidence that many people appear to be subject to simple money illusion, the inability to distinguish between nominal and real quantities (Shiller 1997).

Insights regarding some of the mechanisms through which changes in inflation uncertainty may affect longer-term real economic performance can also be taken from the recent theoretical literature on investment. Investment projects are normally irreversible, in the sense that they are firm-specific or industry-specific and therefore represent sunk costs that cannot be easily recovered once made (Pindyck 1991). If particular investment projects can be delayed, then the timing of such projects may become highly sensitive to the degree of uncertainty regarding their prospective profitability (Pindyck and Solimano 1993). Once a firm irreversibly invests in a project, it gives up its option to invest at some point in the future. Indeed, the value of this lost option is an opportunity cost of a given investment project. To the extent that investment projects are irreversible, any event that leads firms to be less sure regarding the range of possibilities for the returns from prospective investment projects will make it advantageous for them to delay some capital expenditures to obtain more information (Bernanke 1983). The implications of the assumption of investment irreversibility for investment decision-making are likely to be even more important in situations of high levels of aggregate- or industry-wide uncertainty, as opposed to firm-specific uncertainty, in the sense that the potential risk associated with a loss of resale value will probably be much larger (Dixit and Pindyck 1994).

In the long run, increased uncertainty clearly raises the cost of capital, given the assumption of investment irreversibility. For a new firm, higher uncertainty would lower the optimal capital stock (Abel and Eberly 1999).[6] As well, if the economic environment in the future is perceived by firms to be more uncertain than at present, then the required level of profitability on new investment projects will rise, leading to a clear reduction in investment (Caballero 1999).

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6. On the other hand, existing firms would have greater difficulties in selling capital if uncertainty rose, even though in bad times they might wish to do so (Abel et al. 1996).

Moreover, the objective of the promotion of aggregate capital spending is likely to be better achieved by stable and credible macroeconomic policies than by frequent changes in tax rates or interest rates (Pindyck 1991). In particular, a significant increase in uncertainty regarding future economic policies would likely raise the value to many firms of waiting for more information, and lead them to substantially reduce investment expenditures, at least in the short run. Furthermore, models incorporating assumptions such as the aversion of firms to "bad" outcomes or the presence of significant capital-market imperfections are more likely to predict a negative effect of uncertainty on investment (Aizenman and Marion 1999).

The analysis of economic behaviour in models with incomplete markets is also useful in assessing the real effects of changes in inflation uncertainty. Agents in such models are typically assumed to have limited knowledge and abilities in regards to dealing with the future (Magill and Quinzii 1996). As a result, they make use both of sequential spot markets and contracts with limited future commitments. These characteristics of both agents and markets in incomplete-market models imply that an increase in uncertainty regarding future incomes, part of which might reflect higher long-run inflation uncertainty, would lead households to reduce current consumption, while firms would postpone selected irreversible investment projects (Drèze 1999).

The various effects on financial markets arising from greater long-term inflation uncertainty that were discussed earlier in this section may have additional adverse effects on investment and economic growth. To the extent that firms rely more intensively on shorter-term debt to finance their capital spending, their financial risks would rise as a result of increased volatility in the cost of financing. Increased reliance on cash flow would expose companies to greater variability in the availability of financing for future investment expenditures. As a result, they might tend to choose projects with more certain rates of return, avoiding more uncertain but potentially more productive projects.

3. Inflation and Long-Term Inflation Uncertainty

In this section, the trends in inflation uncertainty in Canada are reviewed. As well, the empirical evidence on the relation between inflation and inflation uncertainty is reassessed.

The measurement of the uncertainty concerning an economic variable such as inflation is inherently subjective. Moreover, there is only a limited amount of quantitative information on long-term inflation expectations. Since it is necessary to make use of proxy variables, it seems best to look at a variety of measures of long-term inflation uncertainty.

A measure of long-term inflation uncertainty commonly used in the empirical literature, especially in older studies, is the statistical variability in average long-run inflation. An estimate for Canada at a five-year horizon is shown in Figure 1. This proxy for long-term inflation uncertainty was much lower on average during the second half of the 1990s than during the moderate-to-high-inflation period from 1973 to 1991 (Table 1).

One standard criticism of these statistical measures of uncertainty is that at least part of the statistical variability of a variable is predictable (Crawford and Kasumovich 1996). As an example, the rise in long-run statistical variability in the first half of the 1990s was in part the result of federal sales tax reform, which was announced well in advance of its implementation and therefore highly predictable. An alternative measure would be the dispersion in long-run inflation expectations from a survey of forecasters, businesses, or households. For Canada, Watson Wyatt (2001) summarizes an annual survey of the long-term inflation expectations of economists and portfolio managers, also providing measures of dispersion such as the difference between the upper and lower quartile forecasts and the difference between the maximum and minimum forecasts (Figure 2).[7] Both indicators of long-term inflation uncertainty were considerably lower during the second half of the 1990s than during the higher-inflation period of the 1980s (Table 2).[8]

The validity of survey measures of inflation uncertainty is often questioned, since they do not take account of the level of uncertainty of each individual forecaster (Grier and Perry 2000). However, there is some evidence that the dispersion of inflation forecasts across survey respondents is positively correlated with the uncertainty of each individual forecaster (Zarnowitz and Lambros 1987).

A third approach is to estimate inflation uncertainty on the basis of an econometric model. For instance, generalized autoregressive conditional heteroscedasticity (GARCH) methods have often been used to estimate a model of the variance of the unpredictable outcomes in a variable (Grier and Perry 2000). These techniques, recently applied to both autoregressive and Phillips curve models of inflation using Canadian data, provided some support for a positive relation between inflation and inflation uncertainty, though the statistical evidence was more conclusive for the autoregressive model (Crawford and Kasumovich 1996).[9]

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7. Participants in the Watson Wyatt survey are asked to provide their long-term average inflation forecast for a horizon 6 to 15 years ahead. This survey was formerly conducted by KPMG (1982–2000). The number of respondents in the KPMG survey to the question on their long-term inflation forecast varied between 14 (for both the years 1984 and 1985) and 37 (for the year 2000).
8. These two inflation-uncertainty measures are also briefly discussed in Howitt (1997).
9. The evidence from the autoregressive inflation models may well be more relevant, owing to the high level of uncertainty associated with measuring the output-gap variable in the Phillips curve model (Crawford and Kasumovich 1996).

An alternative econometric approach is to use Markov switching methods to model the inflation process. The application of these methods to Canadian data supported the view that there had been three different inflation regimes during the post-war period, respectively characterized by low, moderate, and high rates of inflation (Ricketts and Rose 1995). Average inflation in the low-inflation state in Canada was estimated to be about 1.5 per cent, and such an inflation regime was clearly evident in the early 1960s.[10] Mean inflation in the moderate-inflation state was estimated to be about 4.5 per cent and this regime seemed to characterize the inflation process in the second half of the 1960s, the early 1970s, the second half of the 1980s, and the early 1990s. A high-inflation process was evident in most of the period from the mid-1970s to the early 1980s. Furthermore, uncertainty regarding inflation was estimated to be about five times higher during the high-inflation regime than in the low-inflation regime. As well, inflation uncertainty in the moderate-inflation regime was estimated to be about 30 per cent higher than in the low-inflation regime.

One criticism of the econometric approach to measuring inflation uncertainty is that such a measure seems to be highly sensitive to model specification (Carruth, Dickerson, and Henley 2000b). As well, both this measure and the statistical indicator of uncertainty are backward-looking in nature, in contrast to the survey-based measure of inflation uncertainty.[11]

In an earlier review of the literature, Golob (1993) concluded that increases in inflation tended to lead to a rise in inflation uncertainty, particularly at long horizons (see also Ball and Cecchetti 1990). O'Reilly (1998) confirmed that the weight of evidence from existing studies indicated that inflation uncertainty would be reduced in a stable and low-inflation environment, though he raised the issue of whether the causal relationship was between inflation and inflation uncertainty, or between changes in the inflation regime and inflation uncertainty. Recent empirical studies continue to provide quite strong evidence that inflation Granger-causes inflation uncertainty in the major industrial countries, including Canada (Grier and Perry 1998, Holland 1995).[12] One of the insights arising from the earlier literature using regime-switching methods was that the effect of inflation was much stronger on long-term inflation uncertainty than on short-term uncertainty (Evans and Wachtel 1993).[13] This positive association between long-term inflation levels and

10. Updated estimates presented in Fillion and Léonard (1997) suggest that the low-inflation regime resumed in Canada over the course of 1992.
11. This is a point in favour of survey-based measures of inflation uncertainty only if most of the survey participants do not use rules based solely on historical information to form their expectations for inflation.
12. On the other hand, Davis and Kanago (2000) suggest that the positive relationship between inflation levels and inflation uncertainty is more evident when the inflation rate is above 10 per cent. In their study, inflation uncertainty is measured by the squared error of inflation forecasts made by the Organisation for Economic Co-operation and Development (OECD).
13. The estimates of inflation uncertainty at different horizons in Evans and Wachtel (1993) are derived using a Markov switching model for inflation.

long-horizon inflation uncertainty for a group of industrial countries was confirmed in Wright (1998), though in the context of a more conventional univariate econometric model of inflation. It may be concluded that the recent empirical literature confirms the presence of a positive correlation between the levels of inflation and long-term inflation uncertainty in moderate-inflation countries. In the case of Canada, both the recent behaviour of various indicators of long-term inflation uncertainty and some econometric evidence suggest that long-term inflation uncertainty may decrease even further in moving from a moderate-inflation regime to a low-inflation regime.

4. Long-Run Inflation Uncertainty and Economic Activity and Financial Markets

This section begins with a review of the recent empirical literature on the relationship between inflation uncertainty and aggregate economic activity. This is followed by an assessment of recent studies on the relation between inflation uncertainty and investment spending, as well as other work examining the effects of inflation and inflation uncertainty on financial markets.

4.1 Inflation uncertainty and aggregate economic activity

Golob (1993), in an early review of applied work on the relationship between inflation uncertainty and aggregate economic activity, had found the evidence to be inconclusive. On the other hand, Holland (1993) argued that it was important to first assume that the inflation process could be subject to regime shifts (i.e., the parameters of the inflation process could change over time), in which case there was almost universal support for a significant negative effect of inflation uncertainty on economic activity.[14]

Subsequent research on this topic has examined both time-series and cross-country evidence. Recent time-series work has supported the proposition that a rise in inflation uncertainty has an adverse effect on real economic activity. For instance, Grier and Perry (2000) found robust evidence that a rise in inflation uncertainty significantly reduces aggregate output growth, using U.S. data over a variety of sample periods and measuring inflation uncertainty with GARCH methods. Lee and Ni (1995) came to a similar conclusion estimating inflation uncertainty with a GARCH model. A study by Davis and Kanago (1996), using U.S. survey data to measure inflation

14. Froyen and Waud (1987) found that a rise in short-run uncertainty about the aggregate price level had a negative, statistically significant effect on aggregate output in both Canada and the United Kingdom. There do not appear to be any subsequent econometric studies examining the relation between aggregate price-level uncertainty and economic activity.

uncertainty and testing for the presence of unit root or cointegrating relationships, concluded that a rise in inflation uncertainty would temporarily reduce real growth over a 1- to 2-year period.[15] Hayford (2000), also using U.S. survey data, found that inflation uncertainty had a negative effect on real output growth, even after controlling for the impact of unemployment uncertainty on real growth.[16] Elder (2000) concluded that there was empirical support for a negative relationship between inflation uncertainty and the level of economic activity, using a multivariate framework. The evidence from these and many earlier time-series studies of a significant negative link between inflation uncertainty and real aggregate activity seems to be quite compelling, especially considering the different estimation methodologies used and the variety of measures of inflation uncertainty.

On the other hand, recent cross-country evidence of the relationship between inflation uncertainty and real activity has been less clear. Barro (1997) found a significant negative relationship between the level of inflation and the growth of real per capita GDP, even when controlling for a wide range of standard determinants of real growth. However, inflation uncertainty, as measured by the standard deviation of inflation, did not seem to play an independent role in explaining income growth. Given the high correlation between inflation and inflation uncertainty, this result is perhaps not surprising. In contrast, Judson and Orphanides (1999), in a cross-sectional time-series study, found a significant negative relation between income growth and inflation uncertainty, as they measured the latter variable using intrayear data. However, their result is relevant only when assessing the effects of long-term inflation uncertainty on real activity, to the extent that short-term inflation uncertainty is highly correlated with long-term inflation uncertainty. The effects of inflation uncertainty, as well as uncertainty regarding other variables, such as government taxation and spending on per capita growth, have also been assessed by Lensink, Bo, and Sterken (1999) using cross-country data and controlling for such standard explanatory variables as initial per capita GDP and the initial stock of human capital.[17] Using extreme bounds analysis (EBA), Lensink, Bo, and Sterken found that their uncertainty measures for both the government variables (deficit, taxes, and government consumption spending) and export sales had robust effects on growth. The evidence of a statistical relationship between their inflation-uncertainty measure and growth was less compelling, though this uncertainty measure

15. However, a permanent change in the level of inflation uncertainty was found to result in a permanent change in the level of aggregate real activity.
16. Hayford (2000) also found evidence both that inflation Granger causes unemployment uncertainty and that the effects of inflation on unemployment uncertainty may be as important as its direct impact on inflation uncertainty, this in regards to accounting for the costs of inflation.
17. Uncertainty was defined to be the standard deviation of the residuals from an autoregressive equation (with a time trend) used to explain the variable under consideration.

had a significant negative effect on income growth in over one-third of the regressions estimated using the EBA technique. More recently, Bassanini, Scarpetta, and Hemmings (2001) concluded that there was strong statistical evidence of a positive relationship between long-term inflation variability (measured as the standard deviation of average inflation over a three-year period) and the level of aggregate economic activity among OECD countries. Their study estimated cross-country time-series regressions, controlling for such factors as fixed investment, human capital, the level of inflation, trade exposure, and various fiscal variables. The level of inflation was found to have an indirect effect on aggregate activity through its impact on fixed investment, though again part of this effect may be reflective of a long-run inflation-uncertainty channel.

While most recent econometric studies suggest that changes in inflation uncertainty clearly have a negative and quantitatively important effect on economic activity, this effect is not estimated very precisely at this time. A permanent 1 percentage point reduction in inflation uncertainty could raise the level of real GDP by at least 2 per cent and as much as 4.5 per cent, according to point estimates from Bassanini, Scarpetta, and Hemmings (2001) and Davis and Kanago (1996).[18] However, 95 per cent confidence intervals for each of these two point estimates bracket a range of 1.2 to 7.8 per cent of real GDP (Table 3). Long-term inflation uncertainty in Canada, as measured by the statistical measure shown in Figure 1, fell about 1.0 percentage point between the 1982–91 period and the second half of the 1990s (Table 1). On the basis of the estimate shown in Bassanini, Scarpetta, and Hemmings (2001), which also used a statistical measure of inflation uncertainty, this would have resulted in an increase in real GDP of at least 1.2 per cent, other things equal.

To sum up, recent time-series studies tend to find strong evidence of a significant negative relationship between inflation uncertainty and aggregate output. At first glance, the empirical support from cross-country evidence for this hypothesis seems to be less conclusive. However, the evidence from some of the cross-country studies is problematic, to the extent that they do not control for the relationship between inflation and inflation uncertainty or focus on short-term as opposed to long-term inflation uncertainty. In particular, the cross-country time-series study by Bassanini, Scarpetta, and Hemmings (2001) appears to provide compelling evidence of a negative and quantitatively significant relationship between long-term inflation uncertainty and economic activity in a group of OECD countries.

18. The effect of inflation uncertainty on economic activity in Grier and Perry (2000), as shown in Table 3, is expressed in terms of output growth instead of the output level.

4.2 Inflation uncertainty and business investment

Evidence of a significant effect of inflation uncertainty on aggregate real activity would be even more compelling if there was empirical support for the proposition that inflation uncertainty also has adverse effects on business investment expenditures. As firms undertake a substantial portion of capital spending in expectations of returns over long horizons, investment should be the component of aggregate spending most likely directly affected by changes in long-term inflation uncertainty.

The empirical literature on the effects of inflation uncertainty on business investment is part of a broader body of work on the effects of uncertainty on capital spending. A recent survey of this broader empirical literature concluded that increases in uncertainty, broadly defined, would indeed lead to a reduction in investment rates (Carruth, Dickerson, and Henley 2000b).[19] Evidence to date suggests that irreversibility effects may be important empirically, in the sense that increased uncertainty increases the value to firms of waiting for more information and therefore delaying selected capital spending projects. For instance, a number of earlier U.K. studies concluded that output uncertainty has a statistically significant, negative effect on investment spending (Driver and Moreton 1991; Price 1995, 1996). Moreover, Carruth, Dickerson, and Henley (2000a) used the international gold price as a proxy for uncertainty about the general economic environment, and found that this measure of uncertainty had a negative and statistically significant impact on U.K. industrial and commercial investment. They have also found evidence of a significant negative effect of a measure of sectoral-price uncertainty on investment (Henley, Carruth, and Dickerson 2000). Ghosal and Loungani (2000) concluded, using U.S. data, that a measure of profit uncertainty had a negative effect on investment, particularly in industries with a preponderance of small firms.

A number of studies have specifically assessed the impact of inflation uncertainty on investment spending.[20] In a path-breaking study, Pindyck and Solimano (1993) found, using data for selected OECD countries, that inflation had a negative and statistically significant effect on the investment rate, though this relation seemed strongest at inflation rates above 5 per cent.[21] However, inflation uncertainty (as measured by the standard deviation of inflation) did not have a significant impact on investment. Eberly (1993) was disturbed by the more significant role played by inflation than by the standard deviation of inflation in explaining the investment rate, and suggested that a high

19. The investment rate is defined as the ratio of investment spending to GDP.
20. Most of these studies include other explanatory variables to help account for the cyclical variability in business investment.
21. The sample of countries did not include Canada.

inflation rate might indicate a higher probability of a "bad outcome" to many firms. Once again, one can question whether the result in Pindyck and Solimano (1993) concerning the relationship between inflation uncertainty and investment is meaningful, in light of the considerable empirical evidence of a strong positive correlation between inflation and various inflation-uncertainty measures.

Ferderer (1993), instead, used measures of the risk premium, calculated from the term structure of interest rates, to estimate inflation uncertainty.[22] He found that his uncertainty measures, especially the long-bond risk premium, had a negative and statistically significant impact on business investment. In particular, the uncertainty measure for the long end of the maturity spectrum seemed to be more important than short-term uncertainty measures for explaining investment spending.[23] As will be shown later, there is some empirical evidence that the long-bond risk premium can be substantially affected by long-term inflation uncertainty.

Huizinga (1993) measured uncertainty on the basis of conditional variance estimates from ARCH models for such variables as inflation, the real wage and output price levels, and the profit rate.[24] He found statistical support for a link between inflation uncertainty and uncertainty about the other three variables. In turn, temporary increases in real wage uncertainty and a permanent rise in uncertainty about the real output price had negative and significant effects on investment levels in the U.S. manufacturing sector.[25] Huizinga used short-term measures of uncertainty, which could be justified on the basis of earlier studies suggesting a high correlation between short-term and long-term measures of inflation uncertainty.[26]

The effect of inflation uncertainty on investment may also vary according to the irreversibility of the type of investment expenditure under consideration. Goel and Ram (1999) argued that spending on housing is likely to be most reversible, while expenditures on machinery and equipment should be least reversible, as they tend to be most firm-specific and industry-specific.

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22. Driver and Moreton (1991), who used a survey-based measure of short-term inflation uncertainty, found that it had a significant negative effect on investment spending only in the short run.
23. Ferderer (1993) also suggests that his measure of inflation uncertainty can help to explain part of the cyclical variation in business investment.
24. Episcopos (1995) used a similar methodology to that of Huizinga (1993) to measure uncertainty, and found that the inflation-uncertainty variable had a negative, though just barely statistically significant, effect on aggregate U.S. private residential and non-residential investment expenditures. He also concluded that uncertainty regarding consumption growth had a strongly adverse impact on investment spending.
25. On the other hand, higher uncertainty regarding the profit rate appeared to be associated with higher levels of investment.
26. However, Cecchetti (1993) argues that it would have been preferable to use direct indicators of long-term inflation uncertainty.

Using data for 12 OECD countries (including Canada), they indeed found that business investment in machinery and equipment was most strongly affected by their measure of long-run inflation uncertainty.[27] However, Goel and Ram recognized that their results would have been more compelling if their specification had included a number of other explanatory variables, such as cash flow.

On the basis of the above studies, there is some empirical support for the view that an increase in inflation uncertainty has an adverse effect on investment spending. However, more research in this area would be useful, with extensions to an assessment of inflation uncertainty on such activities as spending by firms on research and development.

4.3 Inflation uncertainty and financial markets

From the analytical discussion in section 2, it seems likely that financial markets would perform less effectively if inflation and long-run inflation uncertainty rose. Indeed, recent studies of the effects of inflation on both long-term bond and equity markets give considerable empirical support to this view.

First, there is new evidence that the increased inflation uncertainty associated with higher rates of inflation contributes to higher inflation-risk premiums on long-term bonds. For instance, Fung, Mitnick, and Remolona (1999) found that the inflation-risk premium on Canadian five-year bonds was substantially lower during the second half of the 1990s than during the 1980s. Another recent study, using U.S. data, estimated that the average inflation risk premium on five-year bonds was higher during the 1968–90 period than during the low-inflation periods both before 1968 and after 1990 (Veronesi and Yared 2000).

There is also considerable evidence that real equity prices were significantly reduced during the high-inflation period of the 1970s and early 1980s in various industrial countries. Ritter and Warr (2001), using the hypothesis originally put forward by Modigliani and Cohn (1979), suggest that investors tended to incorrectly discount the expected real earnings of firms with the nominal discount rate (instead of the real discount rate), and also did not take account of the real depreciation of the nominal liabilities of firms when estimating their prospective real earnings. The correction of these inflation-induced valuation errors with the return to lower rates of inflation in the United States between 1982 and 1997 is estimated to have accounted for an improvement in the average annual real rate of return on equities of some 5.5 per cent during this period. Since the

27. Their main measure of inflation uncertainty was a five-year moving standard deviation of inflation. A five-year moving average of the level of inflation was also tried as an alternative proxy for inflation uncertainty, with similar results.

inflation rate in the United States decreased about 6 percentage points between 1973–81 and 1982–97, the above estimate implies that the real rate of return on equity recovered about 90 basis points for every 1 percentage point reduction in inflation. Another recent study has come up with a somewhat lower estimate (Sharpe 2001). Barnes, Boyd, and Smith (1999) also found evidence of a negative correlation between inflation and nominal rates of return on equity in many economies that have experienced low-to-moderate rates of inflation. However, this explanation for the downturn in equity prices in the 1970s and early 1980s still needs to be reconciled with the alternative hypothesis that this period of weak stock market prices resulted from the revolution in information technologies and its adverse effects on incumbent firms based on the older centralized computing technologies (Greenwood and Jovanovic 1999, Hobijn and Jovanovic 2000). Pindyck (1983) has also questioned whether such stock valuation errors could have persisted for very long.[28] Even so, to the extent that these results can be applied to Canada, they suggest economically significant effects. For example, even if the estimated effect of inflation on the cost of equity is halved, the reduction in the cost of equity as a result of the decrease in inflation and long-run inflation uncertainty in Canada between 1973–91 and 1992–99 could have been 150 to 300 basis points.

Given the above evidence of the significant adverse effects of inflation on long-term financial markets, one would have expected both firms and households to have relied relatively more on shorter-term financial instruments to meet their need for credit during the high-inflation period. Indeed, the reliance of Canadian firms on long-term financial instruments for their credit needs decreased over the course of the 1970s and then recovered during the past two decades as inflation fell (Figure 3).[29] These shifts were evident in the use of both bonds and debentures (Figure 4)[30] and equity (Figure 5). Similarly, the average duration of bank mortgage loans to households decreased considerably between 1975 and 1985 and then rebounded to some degree between 1985 and 1995 (Howitt 1997, Montplaisir 1996–97). The rise and fall in trend inflation is unlikely to have been the sole factor explaining the longer-term fluctuations in both the composition of business credit[31] and the average duration of mortgage loans, but it surely played a key role, given

28. Pindyck (1983) argued that a rise in inflation, with the associated increase in inflation uncertainty, would raise the riskiness of holding bonds relative to that of equity, and should therefore contribute to higher share prices. He attributed the substantial decline in U.S. real stock prices between 1965 and 1981 to both greater volatility in equity prices and a reduction in the expected return on equity. However, Pindyck admitted in his paper that these two latter developments could have been in part the result of the rise in inflation.

29. The data on business credit and its components are taken from Table E2 of the *Bank of Canada Review*. Long-term business credit is the same as the term "other business credit" used in Table E2, and includes such financing instruments as non-residential mortgages, leasing receivables, bonds and debentures, and equity.

30. See Miville and Bernier (1999).

31. For instance, the share of bankers' acceptances and commercial paper in total business credit has risen considerably in Canada since the late 1970s.

the timing of the decline in the relative use of long-term financing in the 1970s and the subsequent recovery after inflation began to decline in the early 1980s. Cross-country evidence for a group of both developed and emerging economies (including Canada) also provides strong support for a negative relation between the inflation rate and the use of long-term debt by firms (Demirgüç-Kunt and Maksimovic 1999).

The effect of higher inflation uncertainty on the cost of capital and subsequently on the choice of financing instruments by firms likely represents one of the mechanisms through which a rise in inflation uncertainty has an adverse impact on business investment. The above evidence of the effects of inflation (and therefore of inflation uncertainty) on financial markets increases the plausibility of econometric studies that have found a negative relationship between inflation uncertainty and business investment.

Moreover, the importance of a well-functioning financial system is heightened by new work on the relationship between the state of financial development and economic growth. In general, advances in financial sector development lead both to a more productive allocation of capital among competing uses and an improvement in the efficiency with which aggregate savings are transformed into investment (Khan 2000). With improvements in the financial system, firms can finance their activities more easily as less emphasis is placed on physical collateral than on both intangible assets and anticipated cash flows (Rajan and Zingales 1999). Indeed, U.S. evidence suggests that high-technology manufacturing industries are relatively more dependent on external financing than other manufacturing industries (Rajan and Zingales 1998). Furthermore, industries that are more dependent on external financing tend to grow faster in economies that are at a higher stage of financial development. Moreover, new firm creation seems to be facilitated by advances in the rate of development of the financial system (Beck and Levine 2001).

This new literature suggests that the ramifications of high inflation for the level and growth of real activity, through the adverse effects of increased inflation uncertainty on financial markets, may be even greater than previously thought. Indeed, recent empirical research points to a negative correlation between inflation and both financial sector lending to the private sector and the volume of bank assets, when inflation is in the low-to-moderate range (Boyd, Levine, and Smith 2001). Furthermore, there also appears to be a negative correlation between inflation and stock market liquidity and trading volumes.

5. Conclusions

This paper has surveyed recent developments in both the theoretical and empirical literature on the economic implications of uncertainty about the longer-term outlook for inflation. Beginning with a conceptual discussion, it has been noted that economic agents would likely be more uncertain about the longer-term outlook for inflation when the current inflation rate was moderate or high. Predictions of the long-term real interest rate would therefore be more uncertain, which would impair decision-making regarding both investments in plant and equipment and portfolio choices concerning longer-term financial assets. Furthermore, a variety of explanations have been provided as to why indexation arrangements do not arise in economies with moderate levels of inflation. Finally, the literature on both irreversible investment and economies with incomplete markets confirms that a less-stable and less-predictable monetary policy would lead to lower levels of investment expenditure. In general, understanding at a conceptual level of the linkages between inflation, long-run inflation uncertainty, financial markets and institutions, capital formation, and aggregate economic activity has improved considerably during the past decade.

A review of the recent empirical literature has confirmed the positive relationship between inflation and long-term inflation uncertainty. Indeed, Canadian evidence, in the form both of the behaviour of alternative measures of long-term inflation uncertainty for Canada over the past two decades and the econometric study by Ricketts and Rose (1995), suggests that long-term inflation uncertainty was lower in the recent low-inflation period than in the moderate-inflation period from 1983 to 1991.

The recent empirical literature on the effects of inflation uncertainty on real economic activity, investment spending, and financial markets has been described. Empirical time-series evidence provides compelling support for the hypothesis that higher inflation uncertainty leads to a negative and statistically significant effect on aggregate economic activity. While the evidence from recent cross-country empirical research at first glance seems to be less convincing, it appears appropriate to also conclude from that body of research that an increase in inflation uncertainty would have an adverse effect on aggregate output, especially after taking account of the strong correlation between inflation and various measures of inflation uncertainty.

Investment spending is the component of aggregate real GDP most likely to be affected by a major change in the level of long-term inflation uncertainty. A broad empirical literature supports the view that business capital formation is adversely affected by increases in uncertainty of a range of variables. A more limited set of studies generally finds that long-term inflation uncertainty has a negative impact on investment spending.

Moreover, recent empirical work provides new evidence that higher inflation and inflation uncertainty contributed to higher risk premia on both bonds and equity during the 1970s and early 1980s. Indeed, both firms and households in Canada shifted towards greater reliance on shorter-term financing instruments during this period, a shift which was subsequently reversed with the return to lower rates of inflation. The effects of an increase in inflation uncertainty on financial markets likely represents one of the mechanisms through which inflation uncertainty had an adverse impact on investment spending in Canada and elsewhere during the higher-inflation period of the 1970s and 1980s.

Summing up, recent empirical work considerably strengthens the view that moderate-to-high rates of inflation in Canada and other industrial economies during the 1970s and 1980s, operating through the channel of higher long-run inflation uncertainty, had adverse and quantitatively significant effects on financial markets, capital spending, and, ultimately, aggregate levels of economic activity. It has become even clearer, both at a conceptual and empirical level, that low and stable rates of inflation, by reducing the level of uncertainty about inflation over the long term, have contributed importantly to the more-effective functioning of economies in Canada and elsewhere. Recent theoretical developments have improved our understanding of why this is so.

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Figure 1: Statistical Measures of Long-Term CPI Inflation and Inflation Uncertainty

Figure 2: Dispersion of Long-Term Inflation Expectations

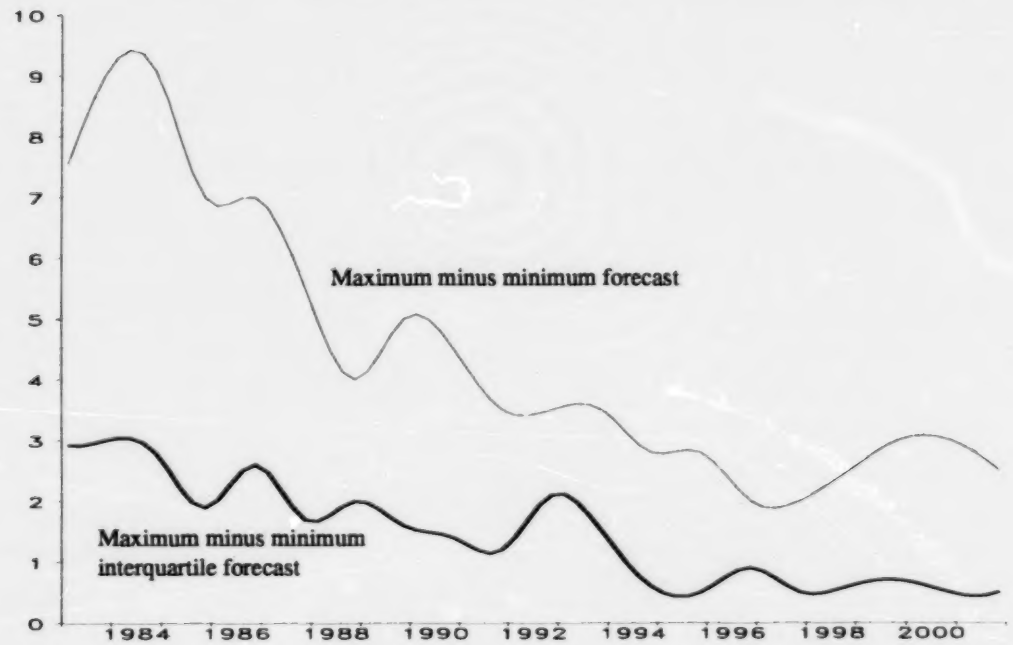

Figure 3: Ratio of Long-Term Business Credit to Total Business Credit

Figure 4: Ratio of Bonds and Debentures to Total Business Credit

Figure 5: Ratio of Equity and Miscellaneous Long-Term Credit to Total Business Credit

Table 1: Statistical Measure of Long-Term Inflation Uncertainty
Canada
(average)

	1973–91	1982–91	1992–95	1996–2000
CPI	1.84	1.64	1.97	0.67
CPI excluding food and energy	1.73	1.69	1.93	0.58

Table 2: Survey Measure of Long-Term Inflation Uncertainty
Canada
(average)

	1982–91	1992–95	1996–2001
Maximum minus minimum forecast	6.16	3.15	2.50
Maximum minus minimum interquartile forecast	2.12	1.18	0.62

Table 3: Selected Estimates of the Effect on Real GDP of a 1 Percentage Point Reduction in Inflation Uncertainty

Study	Per cent change in real GDP*	Inflation uncertainty measure	Countries covered
Bassanini, Scarpetta, and Hemmings (2001)	2.0[1] (1.2 to 2.8)	Long-term statistical.	Selected OECD, including Canada.
Davis and Kanago (1996)	4.5[2] (1.2 to 7.8)	Short-term survey-based.	United States
Grier and Perry (2000)	1.0 [3] (0.4 to 1.6)	Short-term econometric.	United States

* Estimates in brackets show the 95 per cent confidence interval.

1. Estimated coefficient and standard error for effect of inflation uncertainty taken from first column of Table 5 in Bassanini, Scarpetta, and Hemmings (2001). Confidence interval estimate is an approximation.

2. Sum of statistically significant coefficients in second column of Table 4 of Davis and Kanago (1996) used to estimate long-run effect on real GDP. Confidence interval estimate is an approximation.

3. Output measure is industrial production. Effect of inflation uncertainty is on output growth. Estimate of output growth effect is taken from equation (3) of Table II of Grier and Perry (2000), as discussed on page 56 of that article.

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